MINISTRY OF LABOUR AND NATIONAL SERVICE

DUST IN CARD ROOMS

THIRD INTERIM REPORT OF THE JOINT ADVISORY COMMITTEE OF THE COTTON INDUSTRY

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REPORT OF THE JOINT ADVISORY COMMITTEE OF THE COTTON INDUSTRY

THIRD INTERIM REPORT ON DUST IN CARD ROOMS

FOREWORD

The Joint Advisory Committee on Conditions of Work in the Cotton Trade was appointed in November, 1944, to consider and advise on practical methods of implementing certain provisions of the Factories Act, 1937, and other problems.

Two reports on Dust in Card Rooms have been issued already in 1946 and 1952. In the 1952 Report, the exhaust system for carding engines devised by the British Cotton Industry Research Association at the Shirley Institute was favourably mentioned. Since then the work of the Sub-Committee appointed to consider this problem has been concentrated on the improvement and testing of that device. Exhaustive tests, including dust estimations, have been made under laboratory conditions at the Shirley Institute and on a full scale installation in a mill under normal working conditions. A full picture of the results of these tests is given in the body of this Report and, as a result, the Committee has been able to recommend that the exhaust system in its perfected form offers a practicable method of implementing the requirements of Section 47 of the Factories Act, 1937, in cotton card rooms.

I commend the use of this system, known as the Shirley " Pressure Point " system, to the cotton spinning industry not only from the point of view of compliance with the requirements of the Factories Acts but also as a means of preventing as far as practicable the occupational disease of byssinosis. Its installation should provide the means for an improvement in working conditions in card rooms which the cotton industry has been anxious to effect for many years past.

(*Signed*) G. P. BARNETT,

H.M. Chief Inspector of Factories.

72 Bridge Street,
MANCHESTER, 3.

21*st March*, 1957.

To: H.M. Chief Inspector of Factories

Sir,

Joint Advisory Committee of the Cotton Industry
Third Interim Report on Dust in Cardrooms

In August, 1951, we submitted to you the second interim report of our Technical Sub-Committee on Dust in Cardrooms. Since then this Sub-Committee has been concentrating its attention on the development of an efficient system for extracting dust from the main dust producing points on carding engines as near as possible to the point of origin.

The last report described the promising experiments of the B.C.I.R.A. in devising a local exhaust system. Since then, that device, known popularly as the Shirley Dust Hood, has been modified and developed, and subjected to prolonged and rigorous tests under both laboratory and mill conditions. The report from the Sub-Committee, which we now submit for your consideration, contains a full description and illustrations of the device and details of the results of the tests of its efficiency.

Since our last report the composition of your main Committee has been much changed. We record, with regret, the death in February, 1956, of Mr. S. Hird, who had been closely concerned with the problems of the Cotton Industry for so many years. Five members relinquished their places on the Committee on their retirement from office:—Mr. T. P. Threlkeld (Chairman), Sir Andrew Naesmith, Mr. A. C. C. Robertson, Mr. H. S. Butterworth and Dr. F. C. Toy; they have been replaced by Miss A. S. Bettenson (Chairman), Mr. L. T. Wright, Ald. H. Chorlton, Mr. F. Dunkerley and Dr. D. W. Hill. On the official side, Mr. Bramley-Harker has been replaced by Mr. E. Waller, and Mr. C. P. Gourley has joined the Committee. We have heard with deep regret of the death in retirement of our former Chairman, Mr. T. P. Threlkeld, and we wish to put on record our appreciation of the many years of faithful and effective service which he gave to this Committee.

The report of the Sub-Committee is largely self-explanatory and does not require further comment of a technical nature from us. It gives in detail the results of the scientific tests on which its conclusions are based. It will be seen that the Sub-Committee was unanimous in recommending the " Shirley Hood " in its perfected form to this Committee and to the industry as a practicable method of implementing the requirements of Section 47 of the Factories Act, 1937.

We have carefully considered this report and we have also as a Committee seen the device in operation under normal working conditions in a cardroom fitted throughout with the system.

We appreciate that questions will arise that can be settled only with a full consideration of the conditions prevailing in individual mills but we are convinced that after many years of thought and experiment, we have at last reached a point where we can offer guidance to the Cotton Industry in dealing with one of its most intractable problems. We therefore wish to support the conclusions of our Sub-Committee and we commend their report to your notice.

In conclusion, we wish to thank the Sub-Committee and all those others who have contributed of their time and knowledge to this work. In particular, we acknowledge our debt to Dr. Hill and his colleagues of the B.C.I.R.A.

We are,

Yours faithfully,

(Signed) A. S. BETTENSON (*Chairman*)
C. B. CLEGG
GEO. B. FIELDING
H. CHORLTON
F. DUNKERLEY
C. SCHOFIELD
JOHN LINDLEY
DOUGLAS W. HILL
E. WALLER
C. P. GOURLEY
LEWIS T. WRIGHT
F. TITHERINGTON

E. K. BLACKBURN (*Secretary*)

Third Interim Report of Committee "B"

To: Miss A. S. Bettenson,
H.M. Superintending Inspector of Factories,
Chairman of the Joint Advisory Committee for the
Cotton Industry

Madam,

Since our last interim report submitted to the Joint Advisory Committee in February, 1951, we have held six meetings and are now able to report progress substantial enough to justify the consideration of the Main Committee.

It is with regret that we have to report the death of Mr. S. Hird, sometime H.M. Superintending Inspector of Factories, and a respected and valued member of the Committee since its inception.

The composition of the Committee has been altered since our last report by the following resignations, following retirement from office:—

Mr. T. P. Threlkeld (Chairman),
Mr. A. C. C. Robertson, and
Mr. Frank Swift

Particular mention must be made of the valuable services rendered to the Committee by all these members, and especially of the work of Mr. T. P. Threlkeld, H.M. Superintending Inspector of Factories for the East Lancashire Division until August, 1955, who had been for ten years its enthusiastic and energetic chairman.

These members were replaced by the appointment of:

Miss A. S. Bettenson (Chairman),
Ald. H. Chorlton, and
Mr. C. Henniker-Heaton

Mr. L. G. Ebert took over the duties of secretary from Mr. N. Gregson, who was transferred away from this area.

We should like to express our appreciation of the valuable services rendered to the Committee by Dr. F. C. Toy, who has retired from the Directorship of the B.C.I.R.A. His successor, Dr. D. W. Hill, Mr. L. H. C. Tippett and Mr. A. E. De Barr, have also attended our meetings as representatives of the Shirley Institute, and mention must again be made of the help the Institute has given both through the advice of its representatives at our meetings, and the facilities provided for testing the devices.

In the Second Interim Report, our conclusions were summed up in 11 numbered points. Our main efforts since then have been concentrated on experiments in furtherance of point (3), that is, the provision of efficient exhaust ventilation at the dust producing points on the carding engine. The problem has been to evolve an efficient system which would not interfere with the normal working of the card.

The Research Association's promising earlier work was described in the last report and the history since then is one of continuing progress ending in the production of a device (the "Shirley" Dust Hood) which effectively prevents the greater part of the dust evolved in the process from entering the air of the workroom.

The device is designed on the following principles:—

A close study of the action of the carding engine has shown that it is possible to collect, at the source, most of the dust which would otherwise be liberated into the cardroom atmosphere, and also to make use of the action of the card itself to carry the dust to points from which it can easily be removed, and thus to assist in the extraction of the dust.

The carding engine consists essentially of three rapidly rotating cylinders which, in addition to their main functions, act as fans and carry round considerable amounts of air. As a result, zones of high and low air pressure are formed in the card. The low pressure zones are of no great importance in the present connection, but air escaping into the atmosphere from the high pressure zones carries dust with it and is responsible for most of the dust in the cardroom.

The " Shirley " Dust Hood is designed to relieve the high pressure zones and so to remove most of the dust which would otherwise be liberated into the atmosphere. By means of deflector sheets which concentrate relief at the required points the need to exhaust air at a great rate is overcome.

With the " Shirley " Dust Hood, based on the principles explained above, air is exhausted from—

(a) the region around the junction of the card and doffer cylinder,
(b) above the taker-in,
(c) between the flats.

The fly swept into the air by the action of the flat cleaning brush depends on the speed of the brush and may be reduced by using a slowly rotating brush of the Phillipson type. The fly from this source is collected by a sheet of perforated metal which holds the fly but allows air to pass through it. This perforated metal screen has three counter-balance weights so as to hold the screen as close to the brush as possible. The screen is hinged so that it can be swung away to allow the accumulation of flat strips to be removed. A piece of perforated metal in the form of an open-sided box is also used on the top of the coiler. This deflects and traps the fly liberated as the sliver enters the trumper on the coiler.

The deflector shields that keep the dust liberated by the doffer comb and calender rollers within the fanning action of the doffer are made of " Perspex " so that the carding can be inspected readily at any time. These deflector shields are hinged so that piecing-up, stripping and grinding can be done without removing them from the card. The region under the calender rollers has been completely boxed in. This is to collect the fly that falls to the floor from the underside of the web and prevent its being blown about the cardroom by draughts. A door is provided for cleaning purposes.

The high pressure generated between the card cylinder and the taker-in end of the flats produces both tangential and radial airflow. The radial part is dealt with by completely boxing-in the taker-in end of the flats down to the taker-in beater cover and exhausting air from one end. The metal sheets used for this are made in two sections, and are hinged so that they can be raised to allow the taker-in beater cover to be cleaned and the clearer roller to be removed when necessary. (If required, these sheets can be removed completely and replaced very easily and quickly.)

The tangential airflow is restricted by inserting a flexible metal sheet between the flats. This sheet passes over the first blockshaft and then rests on the inside of those flats passing over the flexible bend for about two-thirds of the distance from back to front. The small air space formed at the taker-in end of the flats is shielded by two side pieces which also hold the metal sheet in position. Air is exhausted through one of these side pieces to relieve the pressure inside. It is not necessary to remove this sheet for setting the flats; being flexible, it can be lifted sufficiently to allow adjustments to be made and it will fall into position when released. If required, however, this sheet can be removed in a few minutes.

The portion of the deflector plate over the calender rollers can be hinged backwards to allow the card tenter to piece-up the web. Vacuum stripping of the cylinder and doffer simultaneously can be performed without touching the hood in any way. The doffer can be ground without removing the hood by hinging forward part of the doffer deflector plate. An adjustable jockey pulley is used so that the belt from the card cylinder to the doffer does not touch the air duct. The card can be brush-stripped in a similar way, except that in this case the jockey pulley is not necessary since the doffer is not then driven directly.

With the support of the Experimental Mill Trials Committee, the device was exhaustively tested at the Institute on cotton from a coarse mill and very gratifying results obtained by dust counts (gravimetric).

It was then decided to fit the device experimentally in a mill for a test under normal working conditions. Mr. R. H. Pearce, a member of the Committee, offered generous facilities for these tests at the mill with which he is connected, and our thanks are due to him for the great amount of trouble taken to ensure the success of the experiments, for his kindness to all visitors to the mill and his unflagging enthusiasm and encouragement at all times during the trial period.

The mill specialises in coarse counts spinning, the highest count being about 14's. For the purposes of the test, 32 cards were partitioned off from the remainder of the room and these were all fitted with the "Shirley" Dust Hoods. Air was exhausted from the hoods through a main 22 inch diameter ducting. The fan exhaust was passed through fabric sleeve filters to collect the fly and coarse dust. After passing through the filter, the air was not recirculated, but was passed outside the mill. This installation was tested by dust counts (gravimetric) taken by the staff of the Institute and by further counts (thermal precipitator) taken when a greater number of cards had been fitted with the device throughout the cardroom. At the same time, dust counts were taken in a second cardroom at the mill where the device had not been installed, and on a card fitted with the device at the Institute (thermal precipitator). The results of these tests are given in Appendix "A".

Following the tests, the Sub-Committee met on 5th December, 1956, when the results of the dust counts were discussed. These results were such that the Committee was able to agree unanimously: "That we can now report to the Joint Advisory Committee that a device is available which, in the opinion of the Sub-Committee, will enable the provisions of Section 47 to be observed, and that we can recommend this device to the industry".

At the same time, the Sub-Committee wish it to be known that two other systems of local exhaust similar in principle, but not in detail, have been seen and acknowledgment should be made of the great amount of work which has gone into the development of these systems. We are not yet able to recommend these devices to the Joint Advisory Committee but we are hopeful that further developments may bring them up to a standard of efficiency which will enable us to make a further report on them.

This report would not be complete without mention of the work of Dr. R. S. F. Schilling, who attended one of our meetings and gave an account of his work in the study of respiratory disease caused by cardroom dust.

We should also like to thank Mr. S. Smith, H.M. Chemical Inspector of Factories, for the work on dust sampling which he has carried out for us, and also Mr. Woodhatch who assisted him in this work.

We are,

Yours faithfully,

(Signed) A. S. Bettenson (*Chairman*)
R. H. Pearce
S. Sanderson
Wilfred Bowles
H. Chorlton
A. Roberts
C. Henniker-Heaton
C. P. Gourley

L. G. Ebert (*Secretary*)

30th January, 1957

APPENDIX A

Report on Tests of the " Shirley " Hood for Carding Engines

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1. INTRODUCTION

The quality and quantity of dust emitted from a carding engine depends greatly on the quality of cotton that is being carded, and on the rate of carding. The cottons actually in use are usually (perhaps entirely) mixtures of various grades; hence tests on, say a " pure " grade of Egyptian cotton would not necessarily be relevant to the conditions in any particular mill. Therefore our tests were made on cotton that was in use, and that was known to be of low quality and as dusty as was likely to occur. The " laboratory-type " test at the Shirley Institute was made on cotton that came from the mill where we made our " mill " tests.

The main difference between the two types of test was that the carding engine at the Shirley Institute was a 40 inch Platt, as opposed to the 45 inch cards in the mill. Thus the laps had to be cut, in the former case, from 45 inches to 40 inches, which reduced the weight of a lap from 44½ lbs. to about 40 lbs.

The mill used low quality Indian and American cotton of staple length about 1 inch; and it spun counts of up to 14s, and its carding rate was 650 lbs. per card per week. Even after carding, much trash remained in the cotton, as was shown by the presence of sand, etc. on the draw frames.

The Shirley Institute used this cotton (RD quality) and carded it to sliver hank 0.112 (i.e., 840 yards weighed $\frac{1}{0.112} = 8.93$ lbs.) at a comparable rate.

We believe that this gave a severe test of the " Shirley " Hood.

We found that dust was emitted mainly from the following parts of the carding engine:—doffer (including comb and web), taker-in, between the flats, flats brush, calender rolls, trumpet, and the side of the cylinder.

Our thanks are due to the Shirley Institute, particularly to Dr. Hill, Mr. De Barr, and Mr. Brownsett, for their courtesy and indispensable co-operation and to the Government Chemist, whose staff made the estimations and analyses of our gravimetric samples.

2. NOTE ABOUT THE CHOICE OF INSTRUMENTS

Four types of sampling apparatus were concerned in these tests:—

(a) Thermal Precipitator (Reference 1) which is the most accurate sampling instrument available for this work. It is certainly accurate for particles from the electron microscope's range up to 5 microns (1 micron= $\frac{1}{1{,}000}$th of a millimetre); it is probably accurate in most cases for the range 5 to 15 microns; and it is possibly accurate for the range 15 to 20 microns. Above 20 microns, it becomes definitely inaccurate. It takes each sample over a relatively long period (usually 30 minutes), whereby the more transient fluctuations in the concentration of dust are obliterated.

(b) Kotzé konimeter (Reference 2). This is the most accurate " snap " sampler (i.e., one that takes each sample in a very short period). Its accuracy equals that of the thermal precipitator (within the limits of experimental errors) over a substantial range of sizes (Reference 3).

(c) Salicylic Acid gravimetric apparatus (Reference 4). This collects dust in bulk from the air, for subsequent weighing and/or chemical analysis (in contrast with (a) and (b) above, which takes samples of only a few microgrammes for counting and sizing under a microscope).

(d) Electrostatic Precipitator (Reference 5). This was used by the Shirley Institute to collect dust in bulk, for subsequent weighing.

The gravimetric apparatus collects all particles that are greater than about 0.2 micron; but the mass of a particle is proportional to the cube of its size, so that, gravimetrically, a single particle of 100 microns is equivalent to 125,000,000 particles 0.2 micron in size, or to 15,000 particles 5 microns in size.

In the dust clouds that are commonly found in factories, the smaller particles are much more numerous than large ones, and it is usually quite sound to ignore the large particles if we are interested in the *number* of particles per c.c. of air.

If, therefore, we wish to determine the efficiency of the Shirley Hood in terms of its power to reduce the number of particles in the air, we must base our conclusions on the thermal precipitator.

If, however, we are interested in its power to reduce the *mass* of dust (in effect, the number of large particles) in the air, then we must use the results of a gravimetric test.

From this, it follows that the efficiency of the Shirley Hood as measured by a gravimetric method will be similar to its efficiency *for large particles* as measured by the thermal precipitator.

REFERENCES

1. Watson & Green: M.R.C. Special Report No. 199 (1935), H.M.S.O.
2. Innes: " The Investigation of Injurious Dust in Mine Air by the Kotzé Konimeter ", J.C. hem. Metal & Min. Soc. South Africa, Vol. 18 (1918) p.199.
3. Davies, Aylward & Leacey: " The Impingement of Dust from Air Jets ", Amer. Med. Arch. Indust. Hyg., Oct. 1951.
4. Watson: Trans. Inst. Min. & Metallurgy, Vol. 46 (1936), p.176.
5. Many forms of electrostatic precipitator are known. The one used here is described in the Shirley Institute Bulletin, Vol. XX, No. 2 (1947), p.70.

3. TESTS ON AN ISOLATED CARDING ENGINE AT THE SHIRLEY INSTITUTE

3(1) *Introduction*

A 40 inch Platt card was isolated from the remainder of the room (in which other processes were going on) by means of a tall canvas tent that fitted fairly closely round the card. Samples of dust in the air were taken, as described in the Results following, by means of thermal precipitators and Kotzé konimeters. Members of the Shirley Institute took gravimetric samples of the general air round the carding engine concurrently with these, by means of two electrostatic precipitators. When the Shirley Hood was added, the filtered air from it was returned to the general air inside the canvas tent.

In addition to the general efficiency of the Shirley Hood, as given in Table 2, the Results give a guide on the effects of the device on the dust that comes from particular parts of the carding engine. It can be shown from them that, in general, less dust is produced at a given part; but the dust is somewhat coarser; i.e., it affects the flows of air inside the carding engine in such a way as to change the size distribution of the dust.

3(2)

RESULTS

N.B.—" TP " means " thermal precipitator "; " K " means " Kotzé konimeter "; " S " means " Shirley Hood ".

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
TP.55	Middle of card, and 1 ft. from it, at nostril level. S not fitted.	865		0.40	59.0 81.4 91.4 97.3 99.6 All	0.5 1 2 3 4 5
TP.56		604		0.54	51.6 75.3 87.9 94.7 97.9 99.5 All	0.5 1 2 3 4 5 6.25
TP.57		664		0.46	52.4 77.8 91.6 97.4 99.5 All	0.5 1 2 3 4 5
TP.58	Ditto, but S fitted.	369		0.40	59.5 90.0 97.1 99.0 All	0.5 1 2 3 4
TP.59		Slide damaged				
TP.60		506		0.40	62.3 89.8 98.6 All	0.5 1 2 3
TP.61		640		0.40	59.4 88.4 95.8 99.0 All	0.5 1 2 3 4
TP.62	1 in. over the middle of where the S enclosure of the doffer would be if it were fitted. But S not fitted.	1,110		0.52	48.2 73.6 86.3 93.2 98.0 99.6 All	0.5 1 2 3 4 5 6.25
TP.63		1,030		0.46	52.6 75.6 88.0 94.5 98.2 99.6 All	0.5 1 2 3 4 5 6.25
K.14		850		0.44	53.8 80.4 92.6 96.3 98.4 99.5 All	0.5 1 2 3 4 5 6.25
TP.64		987		0.48	51.3 74.1 87.0 93.2 97.3 99.4 All	0.5 1 2 3 4 5 6.25

RESULTS

N.B.—" TP " means " thermal precipitator "; " K " means " Kotzé konimeter "; " S " means " Shirley Hood ".

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
TP.65	Ditto, but S fitted.	419		0.39	59.0 86.0 93.1 96.6 99.1 All	0.5 1 2 3 4 5
TP.66		473		0.40	62.3 92.5 98.6 All	0.5 1 2 3
TP.67		422		0.32	70.5 95.5 99.4 All	0.5 1 2 3
TP.68		522		0.42	55.7 81.3 92.7 96.8 99.1 All	0.5 1 2 3 4 5
K.15	In the canvas tent before work started. S fitted.	130		0.39	59.9 89.6 96.2 98.6 99.5 All	0.5 1 2 3 4 5
K.16	General air outside the tent towards the end of the day. S fitted.	170		0.35	61.8 90.4 97.0 98.8 99.6 All	0.5 1 2 3 4 5
K.17		180		0.42	56.0 81.9 92.3 96.8 99.1 All	0.5 1 2 3 4 5
K.18	General air outside the tent in the middle of the day. S not fitted. (Concurrent with TP.56 and TP.63.)	127		0.44	53.6 75.4 88.2 94.4 97.7 99.1 All	0.5 1 2 3 4 5 6.25
K.19		191		0.48	52.0 76.0 89.3 95.7 98.6 99.6 All	0.5 1 2 3 4 5 6.25
K.20	At a filter bag that was returning filtereal air at a high level to the room outside the tent. There was dirt on the outside of the bag, and it was of coarse mesh (i.e., efficient only for very large particles).	980		0.54	46.4 71.3 86.3 94.3 97.7 99.4 All	0.5 1 2 3 4 5 6.25
K.21	At the comb. S not fitted.	639		0.40	58.2 81.8 94.4 98.9 All	0.5 1 2 3 4
K.22	At the web when the S enclosure was lifted for a short while.	440		0.32	66.1 96.7 99.4 All	0.5 1 2 3

RESULTS

N.B.—" TP " means " thermal precipitator "; " K " means " Kotzé konimeter "; " S " means " Shirley Hood ".

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
K.23	At the trumpet. S not fitted.	195		0.41	56.3	0.5
					83.3	1
					94.9	2
					97.7	3
					99.6	4
					All	5
K.24	Ditto, but S fitted.	161		0.40	59.0	0.5
					90.2	1
					97.0	2
					98.5	3
					99.5	4
					All	5
K.25		113		0.45	53.7	0.5
					77.1	1
					87.8	2
					94.3	3
					98.0	4
					99.4	5
					All	6.25
K.26	At the side of the cylinder. S not fitted.	256		0.40	62.5	0.5
					88.1	1
					97.4	2
					99.3	3
					All	4
K.27	Ditto, but S fitted.	197		0.42	55.3	0.5
					81.8	1
					92.8	2
					96.4	3
					98.7	4
					99.6	5
					All	6.25
K.28		166		0.43	52.2	0.5
					75.1	1
					89.0	2
					95.5	3
					98.5	4
					99.5	5
					All	6.25
K.29	Between the upper and lower flats. S not fitted.	212		0.36	63.2	0.5
					88.2	1
					96.1	2
					98.5	3
					99.5	4
					All	5
K.30	Ditto, but S fitted.	205		0.42	56.0	0.5
					81.2	1
					93.6	2
					98.3	3
					99.6	4
					All	5
K.31	At Phillipson's Patent flats brush. S not fitted.	330		0.44	55.0	0.5
					80.0	1
					90.9	2
					95.0	3
					97.3	4
					98.7	5
					99.6	6.25
					All	7.5

RESULTS

N.B.—" TP " means " thermal precipitator "; " K " means " Kotzé konimeter "; " S " means " Shirley Hood ".

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
K.32	Ditto, but S fitted.	156		0.42	56.5	0.5
					82.6	1
					93.8	2
					97.5	3
					99.4	4
					All	5
K.33		146		0.46	52.4	0.5
					76.4	1
					89.7	2
					95.1	3
					98.0	4
					99.5	5
					All	6.25
K.34	At the taker-in. S not fitted.	340		0.48	51.3	0.5
					74.0	1
					89.4	2
					95.8	3
					98.5	4
					99.6	5
					All	6.25
K.35	Ditto, but S fitted.	266		0.50	49.8	0.5
					78.1	1
					89.7	2
					96.2	3
					98.5	4
					99.4	5
					All	6.25
K.36	At the calender rolls. S not fitted.	157		0.46	51.5	0.5
					74.2	1
					89.2	2
					95.9	3
					All	4
K.37	Ditto, but S fitted.	249		0.38	63.0	0.5
					90.5	1
					98.3	2
					99.9	3
K.38	At the curtain of fly from the flats brush. S not fitted.	170		0.36	61.0	0.5
					90.0	1
					96.1	2
					98.0	3
					99.4	4
					All	5
K.39	Ditto, but S fitted.	184		0.42	56.4	0.5
					80.7	1
					92.0	2
					97.0	3
					99.5	4
					99.9	5

Shirley Hood

Table 1

Contamination, in " Clean " Air, not controllable by the Hood

N.B.— (i) Sizes are given in microns.
(ii) Concentrations are given in particles per c.c.

Size	0.5	1	2	3	4	5	6.25	Total
K.15	78	39	9	3	1			130
K.16	105	49	11	3	1	1		170
K.17	100	47	19	8	4	2		180
K.18	68	28	16	8	4	2	1	127
K.19	99	46	25	12	6	2	1	191
Average	90	42	16	7	3	1	0	159

Table 2

General Efficiency of the Hood

That is to say, the contamination in the general air around the card when the hood was fitted, compared with that when the hood was not fitted.

Table 2A

Contamination when the Hood was not fitted

Size	0.5	1	2	3	4	5	6.25	Total
TP.55	510	194	87	51	20	4		866
TP.56	312	143	76	41	19	10	3	604
TP.57	348	169	92	39	14	4		666
TP.62	535	282	141	77	53	18	6	1,112
TP.63	540	236	127	67	38	14	5	1,027
K.14	457	226	104	31	18	9	5	850
TP.64	506	225	127	61	40	21	5	985
Average	458	211	108	52	29	11	3	872
Table 1	90	42	16	7	3	1		159
Nett Average	368	169	92	45	26	10	3	713

N.B.— (i) Sizes are given in microns.
(ii) Concentrations are given in particles per c.c.

Table 2B

Contamination when the Hood was fitted

Size	0.5	1	2	3	4	5	Total
TP.58	220	113	26	7	4		370
TP.60	315	139	45	8			507
TP.61	380	186	47	20	6		639
TP.65	247	113	30	15	10	4	419
TP.66	295	143	29	7			474
TP.67	297	105	16	2			420
TP.68	291	134	60	21	12	5	523
Average	292	133	36	11	5	1	478
Table 1	90	42	16	7	3	1	159
Nett Average	202	91	20	4	2		319

Table 2C

By comparing Table 2B with Table 2C, the general efficiency of the hood is shown to be:

0.5 micron	45%
1 micron	46%
2 microns	78%
3 microns	91%
4 microns	92%
Overall efficiency	55%

The overall gravimetric efficiency, as determined concurrently by members of the Shirley Institute was 94% in terms of mass.

4. TESTS IN TWO CARDROOMS IN A MILL

4(1) Disposition of Carding Engines in the Card Room

We took samples in two card rooms; the " Shirley card room ", and the " bottom card room ".

The Shirley Card Room

There were four rows of 21 cards in one corner of a large workroom. At one time 32 had been separated from the rest of the workroom by partitions, but the partitions had been damaged. In what follows, individual cards have been designated by a decimal number, such as 2.11: the " 2 " here means that the card is in the second row from one outside wall, and it is the eleventh card, from the other outside wall, in that row. All the cards were fitted with the Shirley device, but the final 7 cards in each row were not yet connected to the exhaust system, so that their devices were not functioning: i.e., cards 1.15 to 1.21, 2.15 to 2.21, 3.15 to 3.21, and 4.15 to 4.21, were not protected.

The Bottom Card Room

There were five rows of cards along an outside wall. We have designated each card by a decimal number, as above, but the row nearest the wall is considered to be the fifth; thus card 5.16 is the sixteenth card from the left, as one faced the wall, in the row nearest the wall.

There were 25 cards in the first row (the last eleven were stripped down), 19 in the second, third and fourth rows, and 18 in the fifth.

In the following diagrams, the figures are the concentrations found by the thermal precipitator at nostril level in the general area of the card named.

Thus:

	1.	2.	3.
.1			
.2			
.3		1130	

etc.

etc.

means that there were 1,130 particles at nostril level in the general area of card 2.3 (i.e., the third card of the second row).

4(2) Results

Thermal Precipitator

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
TP.1	Card 2.3 in Shirley card room.	1,130		0.30	69.0 92.3 98.0 99.4 99.9	0.5 1 2 3 4
TP.2	Card 3.3 in Shirley card room.	1,720		0.26	75.0 94.3 97.3 99.0 99.9	0.5 1 2 3 4
TP.3	Card 2.7 in Shirley card room.	1,300		0.31	70.0 90.5 96.5 98.6 99.5 99.9	0.5 1 2 3 4 5
TP.4	Card 2.9 in Shirley card room.	1,490		0.32	68.0 92.3 97.8 99.5 99.9	0.5 1 2 3 4

RESULTS

Thermal Precipitator

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
TP.5	Card 2.11 in Shirley card room.	1,180		0.34	64.9	0.5
					87.0	1
					95.1	2
					98.7	3
					All	4
TP.6	Card 2.5 in Shirley card room.	1,340		0.41	59.5	0.5
					89.5	1
					97.5	2
					99.6	3
					All	4
TP.7	Card 3.5 in Shirley card room.	923		0.31	68.3	0.5
					91.3	1
					97.4	2
					99.4	3
					99.9	4
TP.8	Card 3.7 in Shirley card room.	1,470		0.30	69.1	0.5
					91.7	1
					98.1	2
					99.5	3
					99.9	4
TP.9	Card 3.9 in Shirley card room.	982		0.30	70.8	0.5
					92.0	1
					98.4	2
					99.9	3
TP.10	Card 3.11 in Shirley card room.	1,550		0.30	66.4	0.5
					89.9	1
					96.8	2
					98.8	3
					99.6	4
					All	5
TP.11	Card 2.1 in bottom card room.	1,130		0.39	58.3	0.5
					84.8	1
					94.8	2
					98.6	3
					99.9	4
					All	5
TP.12	Card 2.4 in bottom card room.	934		0.32	64.1	0.5
					83.4	1
					92.2	2
					97.1	3
					99.0	4
					99.9	5
TP.13	Card 2.7 in bottom card room.	998		0.37	61.0	0.5
					84.5	1
					93.5	2
					97.5	3
					99.5	4
					All	5
TP.14	Card 2.10 in bottom card room.	905		0.50	50.5	0.5
					76.2	1
					89.8	2
					95.6	3
					98.5	4
					99.5	5
					All	6.25

Thermal Precipitator

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
TP.15	Card 2.13 in bottom card room.	1,750		0.38	60.8 85.0 94.4 98.1 99.4 99.9	0.5 1 2 3 4 5
TP.16	Card 2.16 in bottom card room.	1,250		0.42	55.7 78.1 90.5 96.0 98.5 99.5 All	0.5 1 2 3 4 5 6.25
TP.17	Card 2.19 in bottom card room.	1,240		0.36	60.8 87.5 94.6 98.6 99.9	0.5 1 2 3 4
TP.18	Card 3.18 in bottom card room.	1,170		0.41	58.0 81.4 93.7 98.1 99.9	0.5 1 2 3 4
TP.19	Card 3.12 in bottom card room.	1,520		0.49	51.5 79.5 91.6 97.6 99.6 99.9	0.5 1 2 3 4 5
TP.20	Card 3.6 in bottom card room.	730		0.42	55.9 80.8 92.6 97.2 99.1 99.9	0.5 1 2 3 4 5
TP.21	Card 4.1 in bottom card room.	1,060		0.39	60.4 81.6 92.9 97.4 99.6 All	0.5 1 2 3 4 5
TP.22	Card 4.4 in bottom card room.	813		0.36	63.7 86.3 93.8 97.6 99.5 All	0.5 1 2 3 4 5
TP.23	Card 4.7 in bottom card room.	758		0.37	62.9 84.2 94.0 98.4 All	0.5 1 2 3 4
TP.24	Card 4.10 in bottom card room.	901		0.40	57.1 81.3 92.9 97.4 99.4 99.9	0.5 1 2 3 4 5

Thermal Precipitator

Sample No.	SITE	Particles, greater than 0.4 micron, per c.c.		Size Distribution in microns		
		Before Incineration	After Incineration	Median Size	% up to Given Size	Given Size
TP.25	Card 4.13 in bottom card room.	666		0.42	56.2 81.2 91.8 97.6 99.5 All	0.5 1 2 3 4 5
TP.26	Card 4.16 in bottom card room.	736		0.48	51.9 75.3 87.9 95.4 99.1 All	0.5 1 2 3 4 5
TP.27	Card 4.19 in bottom card room.	862		0.39	59.5 83.0 94.0 98.5 All	0.5 1 2 3 4
TP.28	Card 3.15 in bottom card room.	1,088		0.38	59.7 82.8 93.1 98.0 All	0.5 1 2 3 4
TP.29	Card 3.9 in bottom card room.	695		0.41	56.7 80.8 92.7 97.6 99.6 All	0.5 1 2 3 4 5
TP.30	Card 3.3 in bottom card room.	628		0.40	59.0 82.5 93.4 98.6 All	0.5 1 2 3 4

4(3) Gravimetric Results

Sample No.	Site	Volume of air sampled: cu. metres	Magms. of dust found		Contamination mgms. per cubic metre	
			Total	Incombustible	Total	Incombustible
Grav. 5	Between cards 1.2 and 2.2 in the Shirley card room.	6.78	9.3	4.7	1.37	0.69
Grav. 6	Equidistant from cards 5.9, 5.10, 4.9 and 4.10 in the bottom card room. Sample taken in the afternoon.	2.13	11.1	4.5	5.21	2.11
Grav. 7	Equidistant from cards 4.14, 4.15, 5.14 and 5.15 in the bottom card room. Sample taken in the morning.	3.79	19.7	6.1	5.20	1.61

The incombustible matter was found to be almost entirely Ferric Oxide and Corundum, presumably from the grinding of the card clothing. There was a little quartz in each sample, but its amount, and the amount of the samples, were too small to allow it to be estimated accurately.

Table 3

Distribution of dust (all sizes) in the Shirley card room

(Particles, greater than 0.4 micron, per c.c.)

Row Card	1.	2.	3.	4.
.1				
.2				
.3		1,130	1,720	
.4				
.5		1,340	923	
.6				
.7		1,300	1,470	
.8				
.9		1,490	982	
.10				
.11		1,180	1,550	

Table 4

Distribution of dust in the Shirley Card Room

(Particles, less than 0.5 micron, per c.c.)

Row Card	1.	2.	3.	4.
.1				
.2				
.3		780	1,290	
.4				
.5		797	630	
.6				
.7		910	1,010	
.8				
.9		1,010	695	
.10				
.11		760	1,030	

Table 5

Distribution of dust in the Shirley Card Room

(Particles, ½-1 micron, per c.c.)

Row Card	1.	2.	3.	4.
.1				
.2				
.3		263	332	
.4				
.5		402	212	
.6				
.7		267	332	
.8				
.9		362	208	
.10				
.11		261	364	

Table 6

Distribution of Dust in the Shirley Card Room

(Particles, 1 - 2 microns, per c.c.)

Row Card	1.	2.	3.	4.
.1				
.2				
.3		65	52	
.4				
.5		107	56	
.6				
.7		78	94	
.8				
.9		82	63	
.10				
.11		96	107	

Table 7

Distribution of Dust in the Shirley Card Room

(Particles, 2 - 3 microns, per c.c.)

Row Card	1.	2.	3.	4.
.1				
.2				
.3		16	29	
.4				
.5		28	18	
.6				
.7		27	21	
.8				
.9		25	15	
.10				
.11		43	31	

Table 8

Distribution of Dust in the Shirley Card Room

(Particles, 3 - 4 microns, per c.c.)

Row Card	1.	2.	3.	4.
.1				
.2				
.3		6	15	
.4				
.5		5	5	
.6				
.7		12	6	
.8				
.9		6	0	
.10				
.11		17	12	

Table 9

Distribution of dust in the Bottom Card Room

(Particles, greater than 0.4 micron, per c.c.)

Row	1.	2.	3.	4.	5.
Card					
.1		1,130		1,060	
.2					
.3			628		
.4		934		813	
.5					
.6			730		
.7		998		758	
.8					
.9			695		
.10		905		901	
.11					
.12			1,520		
.13		1,750		666	
.14					
.15			1,090		
.16		1,250		736	
.17					
.18			1,170		
.19		1,240		862	

Table 10

Distribution of Dust in the Bottom Card Room

(Particles, less than 0.5 micron, per c.c.)

Row	1.	2.	3.	4.	5.
Card					
.1		660		641	
.2					
.3			370		
.4		599		517	
.5					
.6			408		
.7		609		477	
.8					
.9			394		
.10		453		514	
.11					
.12			783		
.13		1,070		374	
.14					
.15			649		
.16		694		382	
.17					
.18			678		
.19		757		512	

Table 11
Distribution of Dust in the Bottom Card Room
(Particles, 0.5 - 1.0 micron, per c.c.)

Row Card	1.	2.	3.	4.	5.
.1		300		225	
.2					
.3			147		
.4		180		184	
.5					
.6			182		
.7		234		161	
.8					
.9			167		
.10		233		218	
.11					
.12			425		
.13		424		166	
.14					
.15			251		
.16		279		172	
.17					
.18			273		
.19		332		202	

Table 12
Distribution of Dust in the Bottom Card Room
(Particles, 1 - 2 microns, per c.c.)

Row Card	1.	2.	3.	4.	5.
.1		113		120	
.2					
.3			68		
.4		82		61	
.5					
.6			86		
.7		90		74	
.8					
.9			83		
.10		123		105	
.11					
.12			184		
.13		165		71	
.14					
.15			112		
.16		154		93	
.17					
.18			144		
.19		88		95	

Table 13
Distribution of Dust in the Bottom Card Room
(Particles, 2 - 3 microns, per c.c.)

Row Card	1.	2.	3.	4.	5.
.1		43		48	
.2					
.3			33		
.4		46		31	
.5					
.6			34		
.7		40		34	
.8					
.9			34		
.10		53		41	
.11					
.12			91		
.13		65		39	
.14					
.15			53		
.16		69		55	
.17					
.18			51		
.19		50		39	

Table 14
Distribution of Dust in the Bottom Card Room
(Particles, 3 - 4 microns, per c.c.)

Row Card	1.	2.	3.	4.	5.
.1		16		23	
.2					
.3			9		
.4		18		15	
.5					
.6			14		
.7		20		12	
.8					
.9			14		
.10		26		18	
.11					
.12			30		
.13		23		13	
.14					
.15			22		
.16		31		27	
.17					
.18			21		
.19		16		13	

Table 15

Distribution of Dust in the Bottom Card Room

(Particles, 4 - 5 microns, per c.c.)

Row Card	1.	2.	3.	4.	5.
.1		6		4	
.2					
.3			0		
.4		8		4	
.5					
.6			6		
.7		5		0	
.8					
.9			3		
.10		9		5	
.11					
.12			5		
.13		9		3	
.14					
.15			0		
.16		12		7	
.17					
.18			0		
.19		0		0	

4(4)—General Efficiency of the Hood

4(4) 1. *Estimate without the use of instruments*

(*N.B.*—The size of the smallest particle that is visible to the unaided eye is about 100 microns.)

There was much less visible dust in the Shirley card room than in the bottom card room; the atmosphere in the Shirley card room was not offensive to breathe, in contrast with conditions in the bottom card room; and byssinotics who became distressed in the bottom card room did not become distressed in the Shirley card room.

4(4) 2. *Efficiency in terms of number of particles, as a function of particle size*

It is possible to determine this, by making three assumptions, namely:—

(i) The arithmetic mean of the figures in any one of Tables 1 to 12 is representative of the conditions shown by the figures. The figures in Table 15 are certainly too low to permit this.

(ii) The size distribution of the dust thrown out by the cards in either room is similar to that in the other room.

In terms of number, there was more dust in the Shirley card room than in the other; there was much dust in both. A factor that reduced the contamination in one would not necessarily upset the size distribution. Different general ventilation could change the contamination without upsetting the size distribution, but different settlement of dust (because of different geometries of the rooms) would alter both the contamination and the size distribution. For example, it can be shown that, in turbulent conditions, concentration of any given size of particle

$$= \frac{n}{sA+v}$$

where n = rate of generation of that size of particle in the room

s = settling velocity of that size of particle

A = floor area of the room

v = rate of ventilation of the room

(iii) The efficiency of the Shirley Hood is 45% in the size range below 0.5 micron. If this is so (and there is some reason to believe it), then it is permissible to compare the concentration of any given size of particle in the bottom card room per 100 particles of 0.5 micron size, with the concentration of that size of particle in the Shirley card room per 55 particles of 0.5 micron size there.

If these three assumptions are accepted, then the efficiency in a given size range is:

$$100\ (1\text{-}0.55.\ \frac{S.}{B}\ \frac{Bo}{So})$$

where S = concentration in Shirley Room

So = concentration of 0.5 micron particles in Shirley Room

B = concentration in Bottom Room

Bo = concentration of 0.5 micron particles in Bottom Room

On this basis, the efficiency of the Shirley Hood is:—

Table 16

Overall Efficiency	62%
0.5 micron	45%
1 micron	63%
2 microns	78%
3 microns	85%
4 microns	88%

4(4) 3. *Efficiency in Gravimetric Terms*

The Shirley Institute had found this to be 90% in a " laboratory " test and 84% in a test in a mill, previously. Their present " laboratory " result was 94%.

Our result for the test in the mill was 74% (total dust) and 63% (incombustible dust).

5. SUMMARY OF RESULTS

A graph is attached to show the efficiency, in terms of number, of the Shirley Hood under " laboratory " conditions and under " mill " conditions.

From what has been said earlier, in Part 2 of this report, it will be apparent that the graph of efficiency against size ought to tend asymptotically to the gravimetric efficiency. Within the limits of experimental errors (which are necessarily relatively large in this sort of work) this occurs in these results.

Efficiency (%)

Size in Microns	Overall (by number)	0.5	1	2	3	4	Gravimetric
At Shirley Institute	55	45	46	78	91	92	94
Previous test by Shirley Institute	—	—	—	—	—	—	90
In the Mill	62	45	63	78	85	88	74
Previous test by Shirley Institute	—	—	—	—	—	—	84

S. SMITH,
H.M. Chemical Inspector of Factories

5141 Wt.2025—5040 K.16 7/57 G.&W. G.302

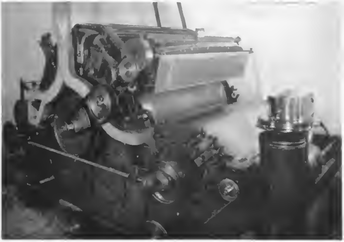


PLATE 1

The shields over the trumpet, the doffer and the flats brush, and the exhaust ducts from the doffer, the taker-in and the flats can be seen.

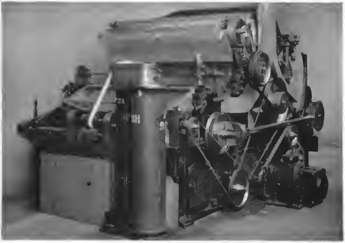


PLATE 2

Remarks as for Plate 1, except that the transparent shield over the comb and web can also be seen.

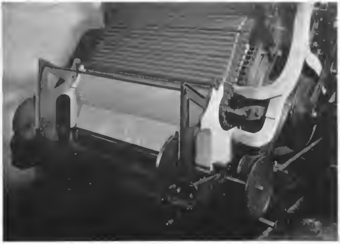


PLATE 3

The shields over the taker-in and over the flats can be seen, as well as the two exhaust ducts for them.

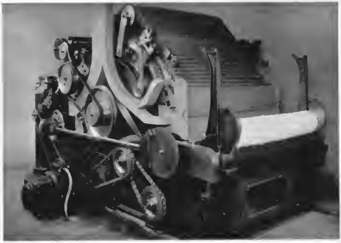


PLATE 4

Remarks as for Plate 3.

PLATE 5
Transparent shield over web lifted to allow gating-up.

PLATE 6
Remarks as for Plate 5.

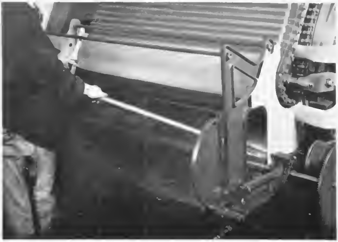


PLATE 7
Photograph shows that the hood does not interfere with the removal of the sealing roller from the taker-in.

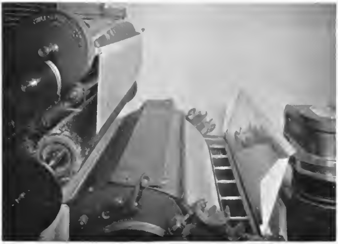


PLATE 8
The transparent shield over the doffer has been lifted to allow the doffer to be ground.

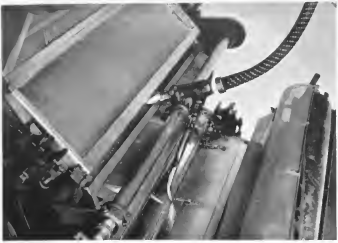


PLATE 9

This shows that the hood does not interfere with stripping by vacuum.

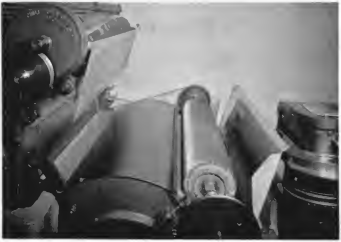


PLATE 10

Brush stripping of the doffer is being done without inconvenience.

Plate 11
Grinding the doffer is being done without inconvenience.

Plate 12
Grinding both the doffer and the cylinder is being done without inconvenience.

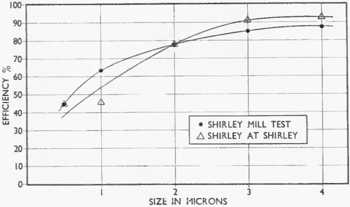
PLATE 13
Parts of the Shirley card room in the Mill where tests were made.

PLATE 14
As above.

[illegible]

[illegible]

PLATE 15
As for 13 and 14.



Graph showing relative efficiency of Shirley Device under test at Shirley Institute and at Mill.